LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA19 | Coleshill Junction

Flood risk assessment (WR-003-019)

Water resources

November 2013

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Department for Transport

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Appendix WR-003-019

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Flood Risk Assessment	003
Community forum area	Coleshill Junction	019

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise of four parts. The first of these is a route-wide appendix (Appendix WR-001-000).

1.1.2 Three specific appendices for each community forum area (CFA) are also provided. For the Coleshill Junction (CFA19) these are:

- a water resources assessment (Appendix WR-002-019);
- a flood risk assessment (FRA); and
- a river modelling report (Appendix WR-004-012).

1.1.3 Maps referred to throughout the water resources and FRA appendices are contained in the Volume 5 water resources map book.

1.2 Scope of this assessment

1.2.1 This FRA considers the assessment of flood risk in this study area, which is defined as the area within 1km of the route within CFA19. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1], which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 This FRA presents baseline (current day) flood risk and post-construction flood risk as a result of the Proposed Scheme and has been written to demonstrate the relative change in flood risk as a result of the Proposed Scheme. Whilst all change in risk status is highlighted, the focus of the document is on the change in risk status to local receptors, particularly existing infrastructure.

1.2.3 A risk-based methodology has been adopted through the application of the source-pathway-receptor model. This model has been used to identify the cause of 'sources' of flooding to and from a development. The identification is based on a review of local conditions and consideration of the effects of climate change.

1.2.4 In order for there to be a flood risk, all the elements of the model (a flood source, a pathway and a receptor) must be present. Furthermore, effective mitigation can be provided by removing one element of the model, for example by removing the pathway or receptor.

1.2.5 Receptors may include people and their properties, business and infrastructure, and the built and natural environment within the range of the flood source which are connected to the source of flooding by a pathway.

[1] Department for Communities and Local Government (2012). *National Planning Policy Framework.*

1.2.6 This FRA has been completed to inform the Environmental Statement (ES) for the works, which will be a key part of the hybrid Bill submission required for the Proposed Scheme. The hybrid Bill is necessary for powers to build the railway, powers to buy land and for planning consent.

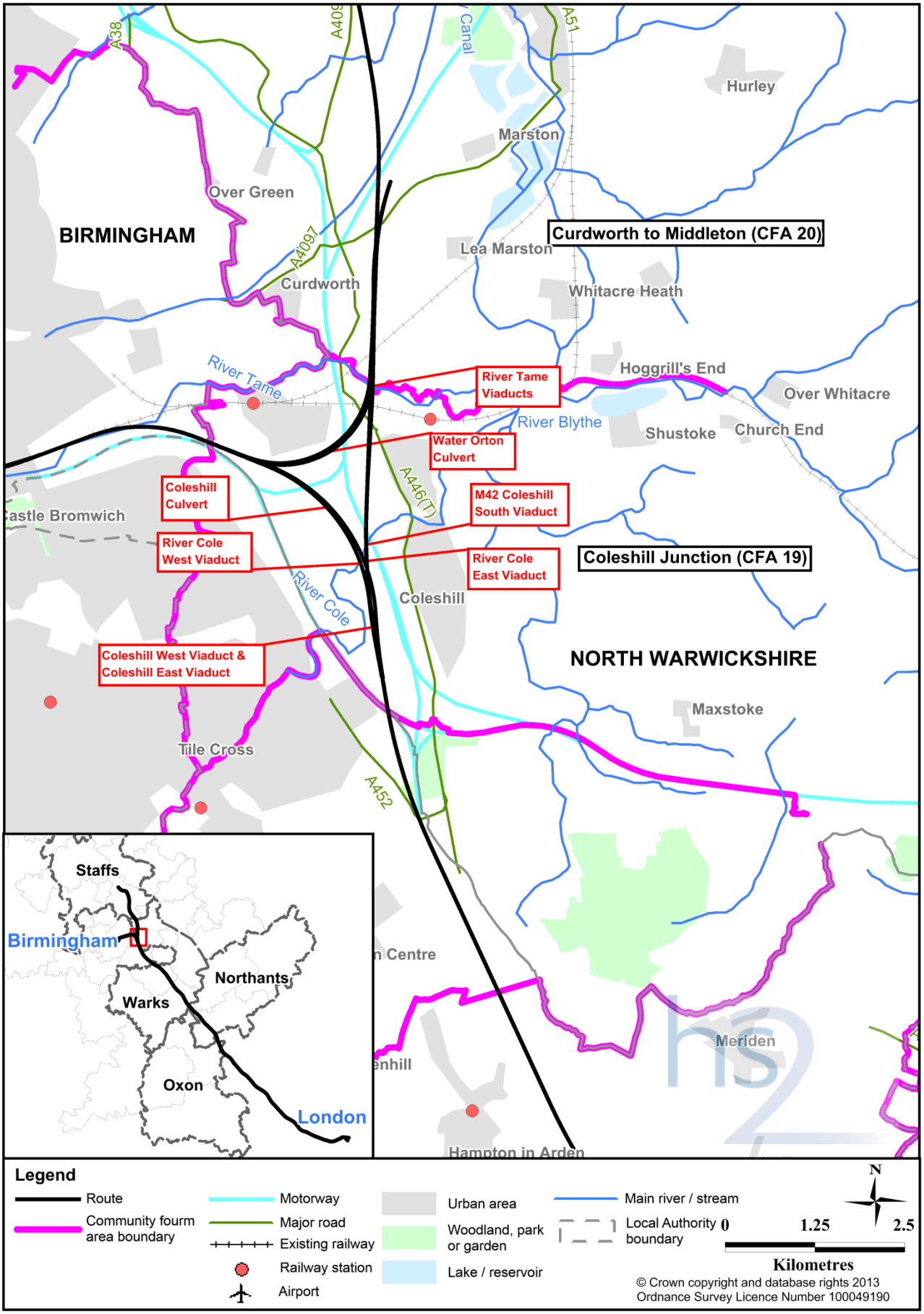
1.2.7 The Proposed Scheme will cross numerous surface water features within this study area, which are the River Cole and its tributaries and the River Tame and its tributaries.

1.3 Location

1.3.1 In this FRA, the study area covers a 13.5km section of the Proposed Scheme in North Warwickshire, where it passes to the west of Coleshill. It extends from the M6 in the south to the boundary between Coleshill and Curdworth parishes in the north and the CFA boundary between Water Orton parish and Birmingham in the north-west. Parts of Solihull are included within the area, west of M6 and the Proposed Scheme. The study area includes land within the communities of Coleshill, Fordbridge, Kingshurst, Smith's Wood and Water Orton.

1.3.2 A location plan of the Proposed Scheme within this study area is shown on Figure 1.

Figure 1: Location plan



2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall, which is a direct source in the short term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewers) in the short or medium term. Stored rainfall, either naturally, in aquifers (groundwater) and natural lakes, or in artificially impounded reservoirs and canals can lead to flooding when the storage capacity of the system is exceeded.

2.1.2 A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea. However given the inland location of this study area, this final source of flooding does not pose a risk.

2.1.3 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.4 In general, receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the route. However, any receptors beyond this where a significant impact was expected were considered in this assessment. The Proposed Scheme includes all associated temporary and permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is required as part of the design to prevent an increase in flood risk in line with recommendations in the NPPF.

2.1.5 The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.6 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the scheme has any potential to influence or alter the risk of flooding to each receptor. The Proposed Scheme will ensure that there is no adverse effect on the risk of flooding to third party receptors, and therefore, where such potential exists, mitigation is proposed based on further analysis.

2.1.7 The FRA defines the baseline flood risk and vulnerability of receptors. This is used to define the value, importance and significance of effects which is provided within the ES.

[2] Department for Communities and Local Government (2012). *National Planning Policy Framework Technical Guidance*.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Watercourse[3]		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water/ overland flow[4]	No FMfSW	FMfSW <0.3m for 1 in 200 year event	FMfSW >0.3m for 1 in 200 year event and FMfSW <0.3m for 1 in 30 year event	FMfSW >0.3m for 1 in 30 year event	
Groundwater[5]		Very low-low	Moderate	High-very high	
Drainage and sewer systems[6]	No sewer in vicinity of site	Surcharge point >20m from site and no pathways	Surcharge point within 20m of site and restricted pathways	Sewer network crosses site and pathways exist	
Artificial sources[7]	Outside of inundation mapping/no pathway exists	Within inundation mapping/pathway exists			

2.3 National planning policy framework

2.3.1 This assessment of flood risk makes use of the NPPF which is the Government's planning policy in relation to development and flood risk. It is set out within the NPPF that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. The NPPF requires that proposed development located within Flood Zones 2 and 3 is assessed in relation to flood risk. This includes both flood risk to the development and any increases in flood risk elsewhere as a result of the development, with an allowance for climate change.

2.3.2 Methods used to ensure that development is at the lowest possible risk and that the development is safe without causing an increased risk elsewhere includes the application of the Sequential and Exception Tests. However the Sequential Test has been considered as part of the overview FRA for the Proposed Scheme presented in Volume 3 of the ES and hence has not been repeated in this FRA.

[3] River flood risk taken from the Environment Agency Flood Zone mapping or hydraulic modelling carried out for this FRA.
[4] Surface water flood risk taken from the Environment Agency Flood Maps for Surface Water (FMfSW).
[5] Groundwater flood risk taken from local flood risk assessment reports.
[6] Identified using the Severn Trent Water's assets network.
[7] Risk from reservoir flooding identified using the Environment Agency reservoir inundation mapping, canal flooding taken from identifying proximity of the Proposed Scheme to canals from Ordnance Survey mapping.

Flood zone classification

2.3.3 The NPPF splits the Environment Agency's Flood Map into three separate Flood Zones. These Flood Zones should be used in determining the appropriateness of proposed development uses and they represent flooding without flood defences in place.

2.3.4 The Flood Zones are defined as:

- Flood Zone 1 – areas with a 'low probability' of flooding and where the annual probability of flooding is lower than 0.1% for either river or sea flooding. The NPPF imposes no constraints upon the type of development within Flood Zone 1;
- Flood Zone 2 – areas with a 'medium probability' of flooding and where the annual probability of flooding is between 0.1 and 1.0% for river flooding or between 0.5 and 0.1% for sea flooding. The NPPF recommends that Flood Zone 2 is suitable for most types of development with the exception of 'highly vulnerable' land uses; and
- Flood Zone 3 – areas with a 'high probability' of flooding and where the annual probability of flooding is 1.0% or greater for river flooding or 0.5% or greater for sea flooding. The NPPF recommends that appropriate development is based upon a further classification of Flood Zone 3: 3a high probability and 3b functional floodplain (where water has to flow or be stored in times of flood).

2.4 Local flooding planning policy documents

2.4.1 The local policies for this study area with implication in relation to flood risk are:

- North Warwickshire Local Plan 2006[8] – ENV8 Water Resources. Policy ENV8 requires that water resources are safeguarded and enhanced and that development is protected from floodwater. In relation to flood risk this policy requires that the Sequential Test is applied when considering proposed development locations. In addition it requires that new development has satisfactory surface water drainage including the use of Sustainable Drainage Systems (SuDS) where appropriate and ensures access to watercourses for maintenance where required; and
- North Warwickshire Local Plan 2006 – ENV12 Urban Design. In relation to flood risk and water resources, policy ENV12 states that development will only be permitted if all the elements of the proposal are well related to each other and harmonise with both the immediate setting and wide surrounds to present a visually attractive environment. In addition the existing natural features are treated as an integral part of the development.

2.4.2 Emerging policy documents have been submitted to the Secretary of State for examination. In relation to this study area, this includes the North Warwickshire Local Plan Core Strategy with submission in February 2013.

[8] North Warwickshire Borough Council (2006). *North Warwickshire Local Plan*.

2.4.3 The Warwickshire Strategic Flood Risk Assessment (SFRA)[9] and Warwickshire Preliminary Flood Risk Assessment (PFRA)[10] aid the Council in preparing sustainable policies for the long-term management of flood risk and improving existing emergency planning procedures. The SFRA is used as an evidence base to promote the location of future development primarily in low flood risk areas. This SFRA has been used to inform this FRA.

2.5 Historical sources of flooding

2.5.1 The historical flooding which has occurred either at the location of the route or in close proximity has been determined as part of this FRA. These areas of historical flooding have been identified because places which have flooded in the past may be more susceptible to flooding in the future. Two sources of data relating to historical flooding have been used: local authority information (the relevant SFRA and PFRA) and extents of historical sources of river flooding as provided by the Environment Agency.

2.6 Flood risk approach

River flooding approach

Crossing locations

2.6.1 To determine the river flood risk at locations where the route will cross watercourses and to identify any changes in flood risk as a result of the Proposed Scheme, either existing hydraulic models have been used where available or new hydraulic models have been constructed. Where new models were required flows have been determined in line with current flood estimation guidelines[11].

Flow estimation

2.6.2 Existing hydraulic modelling was available to assess flood risk at the River Tame viaducts (Volume5: Map Book – Water resources, Map WR-01-032, C5) through the use of the River Tame Hazard Mapping Study[12], and hence flows at these locations were taken from the existing River Tame model. In addition, existing hydraulic modelling was available to assess flood risk at the crossings over the River Cole, in particular the M42 Coleshill South viaduct, the River Cole West viaduct, River Cole East viaduct and the Coleshill West viaduct (Volume5: Map Book – Water resources, Map WR-01-032, G5, F6 and F5) through the use of the River Cole Flood Risk Mapping Study[13].

2.6.3 The other watercourses which will be crossed by the route within this study area have no known detailed modelling available. Where Flood Zones are associated with these watercourses, the outlines have been determined through the use of broadscale topographic data, which are considered to be a rough guide when determining areas at risk of flooding and hence have not be used for the design of engineering works. There are other watercourses which have no associated Flood Zones. Flows for these

[9] Warwickshire County Council (2008). *Strategic Flood Risk Assessment. Volume 1* completed by Halcrow Group Ltd.
[10] Warwickshire County Council (2011), *Warwickshire Preliminary Flood Risk Assessment*. Completed by Royal Haskoning on behalf of Warwickshire County Council.
[11] Environment Agency (2012), *Flood estimation guidelines*.
[12] Environment Agency (2009), *River Tame Hazard Mapping*. Completed by Halcrow on behalf of the Environment Agency.
[13] Environment Agency (2007), *River Cole Flood Risk Mapping Study*.

watercourses, at the location of the proposed crossings, have been determined for the 1 in 20 (5%), 1 in 100 (1%), 1 in 100 (1%) with a 20% allowance for climate change and 1 in 1000 (0.1%) annual probability events.

2.6.4 A quick estimation of flow was produced at the crossing locations using the Revitalised Flood Hydrograph model (ReFH) where the contributing catchments were represented within the Flood Estimation Handbook (FEH) CD-ROM[14]. A FEH calculation record for the estimation of flow using ReFH is provided in the river modelling report (Volume 5, WR-004-012).

2.6.5 Small catchments (normally less than approximately 0.5km^2), such as at the River Tame tributary and the River Cole tributary (see Table 2), are not represented on the FEH CD-ROM and hence it is not possible to either produce a catchment boundary or determine catchment descriptors (required for the estimation of flow) from this source. For crossings where the watercourse is not represented within the FEH CD-ROM, a scaling method based on area, in line with the flood estimation guidelines was carried out. Contributing catchment areas at crossing locations were determined using topographic and Ordnance Survey (OS) mapping; in areas of uncertainty slightly larger catchments were defined as a conservative approach. The flows estimated through the use of ReFH for catchments in the northern study areas of the Proposed Scheme were used to determine a scaling factor. The greatest flow per km^2 was used as a scaling factor for the catchments in this study area which were manually determined. An error allowance of 10% was also applied to reduce the risk of underestimating flows.

Modelling approach

2.6.6 At river crossing locations where existing hydraulic models were available, and were in a suitable format for this assessment, these were used. Specifically, the River Tame Hazard Mapping Study[12] model and the River Cole Flood Risk Mapping Study[13] model were used in this study area. These models were rerun for the baseline (current) scenario and for the Proposed Scheme scenario. At crossings where suitable models were not available new hydraulic models were built utilising the new high resolution Light Detection and Ranging (LiDAR) data provided for the Proposed Scheme. Further detail in relation to the hydraulic modelling is included in the river modelling report, (Volume 5, WR-004-012).

2.6.7 The inflow boundaries were mostly applied as steady state flows with unsteady state flows applied for certain watercourses. For watercourses with floodplain attenuation such as ponds and lakes or significant obstructions to flow (e.g. due to embankments), the inflows were modelled using unsteady state hydrographs. These models were run at longer durations covering the period of the hydrograph and attenuation. The resulting baseline (current) models were run for the 1 in 100 (1%) annual probability with an allowance climate change and 1 in 1000 (0.1%) events over a range of durations depending upon the flow conditions.

2.6.8 The Proposed Scheme models included either viaducts or culverts depending on the scheme design. The railway embankments were represented by modifying the

[14] Centre for Ecology and Hydrology (2009) *FEH CD-ROM Version 3*, ©NERC (CEH).

modelled DTM at those locations. The 1 in 100 (1%) annual probability with an allowance for climate change peak flood levels upstream of the crossings were compared to the baseline (current) levels to assess the change in flood risk. The 1 in 1000 (0.1%) annual probability peak levels were extracted to inform the vertical alignment of the track.

River flood risk elsewhere along the route

2.6.9 In addition to watercourse crossings, there are sections of the route which are located in areas potentially at risk of river flooding. These have been identified through the use of the Environment Agency Flood Zone mapping. This mapping has been used in preference to SFRA mapping as it is considered more up to date and hence likely to best reflect areas at risk. River flood risk to these sections of the route needs to be determined both to prevent an unacceptable risk to the Proposed Scheme and to prevent it increasing flood risk as result of a reduction in floodplain storage.

Summary of river flooding approach

2.6.10 Due to the number of river crossings, varying complexities, and the amount of data and information available for each, at some locations the modelling approach is highly specific. These locations have been reported as such and further information is included in the river modelling report (Volume 5, WR-004-012).

Surface water flood risk

2.6.11 The baseline (current) assessment of surface water flood risk was completed using the Flood Maps for Surface Water (FMfSW). The maps utilised for this assessment are listed as:

- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.1m deep;
- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.3m deep;
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.1m deep; and
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.3m deep.

2.6.12 This mapping identified sections of the route which currently are at specific risk from surface water flooding. The risk classification assigned at each location is dependent on which FMfSW the receptor is located within.

2.6.13 The Proposed Scheme has the potential to interrupt surface water flow which would require mitigation to prevent an increase in flood risk. In addition, other design elements such as landscaping will alter the permeability of the ground and hence modify sections of the surface water catchments. The assessment involved determining the land drainage catchments, surface water run-off from these catchments and the capacity of Sustainable Drainage Systems (SuDS) and culverts.

2.6.14 Land drainage catchments were identified using topographic data (primarily 5m contours, or 1m contours on small or unclear catchments). The assumption was made that linear features such as roads and railways do not act as a cut off for overland flow.

2.6.15 The calculation of greenfield run-off rates from existing catchments was undertaken using the online SuDS tool[15]. A growth factor of 30% was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during this event with an allowance for climate change. A factor of 62% (based on calculations using the Flood Studies Supplementary Report 14[16]) was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during the 1 in 1000 (0.1%) annual probability event.

2.6.16 Run-off from modified sections of the catchment as a result of the Proposed Scheme (e.g. landscape areas) which alter the permeability was determined using the Institute of Hydrology methodology[17] with a value of 0.5 for the soil parameter and a safety factor of 1.2.

2.6.17 Storage volumes were calculated using the online SuDS tool[15] assuming that landscape areas will be impermeable. The storage volumes required were taken to be the sum of the attenuation and long term storage as a conservative approach.

2.6.18 The calculations for the proposed drainage design have been completed in line with the requirements in Volume 1, Section 9.

Groundwater flood risk

2.6.19 Groundwater bodies and aquifers present within a 1km buffer of the route have been identified and named on available web-based mapping data provided for the purposes of the Proposed Scheme.

2.6.20 Field investigations have not yet been undertaken due to limited access to land and the need to integrate investigative requirements from several disciplines.

Sewer systems flood risk

2.6.21 The risk of flooding from the sewer network has also been addressed in this FRA. The sewer network data was provided for this assessment by the relevant water company, Severn Trent Water, to determine locations where the route and other design elements which will be located at areas of risk.

Other sources of flood risk

2.6.22 Reservoir flood risk was assessed using the reservoir inundation maps as shown in Volume 5: Map Book – Water resources, map WR-01-032. The purpose was to identify areas along the route that were at risk of flooding if any reservoirs in the vicinity were to fail.

2.6.23 Canals have been identified as another source of potential flood risk, and therefore canals that will be crossed by the Proposed Scheme have been identified in the assessment.

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[15] HR Wallingford (2013), UK Sustainable Drainage Guidance and Tool. The Greenfield run-off estimation for sites tool. http://geoservergisweb2.hrwallingford.co.uk/uksd/greenfieldrun-off.aspx.
[16] Institute of Hydrology (1983), *The Flood Studies Supplementary Report Number 14. August 1983.*
[17] Institute of Hydrology (2004), *Report number 124, Flood Estimation for Small Catchments.*

3 Design criteria

3.1 Principal design criteria

3.1.1 The Proposed Scheme will provide a safe and reliable high speed rail link which will be compatible with the existing rail network and also HS1.

3.1.2 The Proposed Scheme will provide a 'passenger' only service and not 'freight' operation.

3.1.3 The design shall seek to ensure that any impacts as a result of its development will be designed out or minimised as far as practicably possible.

3.2 Flood risk design approach statement

3.2.1 The overall project seeks to ensure that there will be no increase in flood risk to any existing receptors as a result of the Proposed Scheme. This will be achieved by ensuring that overall flood storage capacity is maintained including an allowance for climate change.

3.2.2 In line with the NPPF technical guidance, increases in peak rainfall intensity and peak river flow of 20%, as a result of climate change, have been allowed for as per the period 2085 to 2115. This 20% increase has been used for the purposes of assessing flood risk. However, the hydraulic modelling involves sensitivity testing which includes a 20% increase, in addition to the 20% allowance for climate change.

3.2.3 All underbridge and viaduct crossings will be designed to allow the 1 in 100 (1%) annual probability flow with an allowance for climate change to pass underneath. Upstream water levels will not be increased and a minimum of 600mm freeboard will be provided to the bridge soffits above this level which will allow for debris should flooding occur. On main rivers, where possible, a freeboard of 1m has been allowed.

3.2.4 Main river underbridges and viaducts will also accommodate river maintenance requirements and allow for a 5.3m vertical clearance above the floodplain ground level.

3.2.5 Culverts have been designed to convey the 1 in 100 (1%) annual probability flow (with allowance for climate change), with a freeboard of 300mm as a minimum applied for the culvert design. The design has also taken into account submerged inverts and the inclusion of mammal ledges.

3.2.6 River crossings will minimise any requirement for replacement floodplain storage areas.

3.2.7 The proposed rail infrastructure will be protected against inundation in the 1 in 1000 (0.1%) annual probability flood event. This will be achieved through ensuring a freeboard of 1m above the 1 in 1000 (0.1%) annual probability flood level. The railway drainage will be designed to have capacity up to the 1 in 100 (1%) annual probability peak rainfall event. However the design will also ensure that the flood level does not exceed 1m below the track level during the 1 in 1000 (0.1%) annual probability rainfall event.

3.2.8 All drainage will be attenuated in order that peak surface water run-off from the proposed infrastructure is no greater than the existing current day baseline run-off under the 1 in 100 (1%) annual probability peak rainfall event.

3.2.9 All drainage will be designed to ensure that disruption to existing groundwater flood flows will be kept to a minimum, both during and following construction of the permanent works.

3.3 Cross drainage design approach statement

3.3.1 The drainage design will ensure that there is no increase in run-off to the receiving watercourse as a result of the Proposed Scheme.

3.3.2 Surface and ground water drainage shall be provided so as to ensure that water levels do not rise above a 1m freeboard below the rail level. The route will be designed to ensure safe operation of trains during a 1 in 1000 (0.1%) annual probability event.

3.3.3 As part of the drainage design an allowance of 30% has been added to design events for climate change.

4 Data sources

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, overland flow (surface water), rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The route will lie entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are:

- OS 1:10,000 mapping;
- topographic survey commissioned for the purposes of the Proposed Scheme (200mm grid resolution LiDAR survey, in DTM and digital surface model format);
- Environment Agency Flood Zone mapping and historic flood mapping;
- Environment Agency website for reservoir inundation mapping;
- Warwickshire SFRA[9];
- Warwickshire PFRA[18];
- Environment Agency national surface water flood mapping datasets specifically the Midlands FMfSW; and
- Severn Trent Water asset mapping.

4.1.4 A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation is undertaken, specifically hydraulic modelling for the areas at risk from river flooding.

[18] Warwickshire County Council (2011), *Warwickshire Preliminary Flood Risk Assessment*. Completed by Royal Haskoning on behalf of Warwickshire County Council.

5 The Proposed Scheme

5.1 Permanent works

5.1.1 The general design of the Proposed Scheme is described in Volume 2, Section 2.2. The following section describes the main features of the Proposed Scheme in this study area, which are specifically relevant for this FRA.

Overview

5.1.2 The Proposed Scheme through this area comprises three sections of railway line, which are the main line, the Birmingham spur and the north chord. Together these comprise the triangular 'Delta' junction.

The main line

M6/M42 junction to the River Cole

5.1.3 The main line will enter the area in the south as it passes over the M6 at junction 4 (Volume 2: CFA19 Map Book, Map CT-06-108b, F5). It will continue on a short embankment before another viaduct across a loop slip road that exits the M42 at junction 7a to join the southbound M6. The main line will then run on an embankment before crossing part of the River Cole floodplain on viaduct. It will then pass onto embankment at Coleshill Hall Farm, including a bridge over the B4114 Birmingham Road, before passing over the Birmingham Spur southbound track and then back onto embankment.

5.1.4 Key features of this section, which have been assessed in this FRA, will include:

- a drainage pond with access from Coleshill Heath Road;
- a drainage pond on the west side with access from the A446 Lichfield Road;
- a viaduct, approximately 460m long over the River Cole floodplain (Volume 2: CFA19 Map Book, Map CT-06-109, F6). The viaducts will be up to 16m above ground level;
- an embankment, approximately 320m long, with a height of between approximately 12m and 16m, extending up to the viaduct that crosses the River Cole; and
- realignment of Manor Drive from a point 400m south-east of Coleshill Manor Office Campus.

River Cole to River Tame

5.1.5 The main line will cross the River Cole on viaduct. The River Cole will be realigned for approximately 730m to pass between the piers of the main line and adjacent Birmingham spur viaducts. The design for the river ensures that at least as much open water channel will be provided as existing and that the speed of flow is not increased downstream. The realignment will form part of a broader area of ecological mitigation and replacement floodplain storage works extending along the revised river corridor.

5.1.6 The main line will then cross the M42/M6 Toll on a box structure before continuing on viaduct to cross Gilson Road, which will be realigned to the south of its present route.

The main line will then run onto a short length of embankment before passing through the higher ground in cutting at Gilson, then returning to embankment before crossing the A446 Lichfield Road on box structure. After a short embankment through the Coleshill Industrial Estate, the main line will then cross the Birmingham to Nuneaton Line on viaduct and the sewage treatment works on embankment, before leaving the area at the viaduct crossing of the River Tame.

5.1.7 Key features of this section, which have been assessed in this FRA, will include the following (Volume 2: CFA19 Map Book, Maps CT-06-109, E5 to CT-06-111a, C4):

- a viaduct, approximately 130m long, will cross over the River Cole and its floodplain, followed by another viaduct approximately 320m long;
- aquatic and wet grassland improvements will be undertaken within the River Cole floodplain, in association with replacement floodplain storage works;
- a drainage pond to the east with access from the realigned Gilson Road;
- a cutting, approximately 580m long and up to 8m deep, immediately to the east of the core area of Gilson (Volume 2: CFA19 Map Book, Map CT-06-110, C6);
- a drainage pond to the west with access from the A446 Lichfield Road;
- a pair of viaducts carrying the main line and southbound Leeds spur tracks over the Birmingham to Nuneaton Line; and
- a railway access road from the A446 Lichfield Road to a drainage pond on the west side and for railway maintenance.

The Birmingham spur

5.1.8 The Birmingham spur will start to leave the main line at approximately 500m south of the point where the route crosses the B4114 Birmingham Road. The Birmingham spur lines will pass onto separate landscaped and vegetated embankments curving around to the north-west, through the east side of the Coleshill Manor Office Campus. The Birmingham spur lines will rise to cross the M6/M42 link roads on two separate viaducts, then two further embankments will take the Birmingham spur lines around the southern side of Water Orton towards Attleboro Farm. The southbound Birmingham spur continues westwards to the boundary with the Castle Bromwich and Bromford area (CFA25).

5.1.9 Key features of the Birmingham spur section of the route will include two different layouts prior to the River Cole viaducts – one for the southbound lines (on the eastern side); and one for the Birmingham-bound lines (on the western side), as follows (see Volume 2: CFA19 Map Book, Maps CT-06-109, B6 to CT-06-134a, E6):

Southbound

- a viaduct, approximately 460m long, carrying the single track of the southbound Birmingham spur over the River Cole floodplain; and
- a cutting, approximately 270m long, up to approximately 7m deep carrying the southbound Birmingham spur track.

Birmingham-bound

- two parallel viaducts approximately 110m and 140m long over the realigned River Cole and its floodplain; and
- a drainage pond will be constructed to the west of the embankments, at the southern end.

5.1.10 A drainage pond and pumping station will be constructed in the angle between the existing and proposed Attleboro Lane alignments, north of the Birmingham spur.

North chord

5.1.11 From west to east, the Birmingham-bound line will split from the Birmingham spur in cutting to pass under the Birmingham spur southbound line, before rising up onto embankment as it curves to the north. The northbound line (closest to Water Orton) will run on embankment as it diverges from the southbound Birmingham spur line and then curve to the north. The northbound line will cross the River Tame and leave the area on viaduct. The Birmingham-bound line will stay on viaduct and tie in with the main line after leaving the Coleshill Junction area.

5.1.12 Key features of this north chord section of the route will include the following (see Volume 2: CFA19 Map Book, Maps CT-06-134, E6 to CT-06-111a, C4):

- a cutting, approximately 500m long and up to 5m deep, carrying the Birmingham-bound line of the north chord; and
- realignment of parts of the watercourses running to the south of Water Orton, which will be integrated with the ecological mitigation areas to either side of the north chord.

5.1.13 Two drainage ponds will be constructed, one on the north side of the route near Coleshill Road and the other to the west of the railway, adjacent to the Birmingham to Nuneaton Line just east of the A446 Lichfield Road.

5.1.14 The route will leave the area in the north as it crosses over the River Tame on viaduct and in the west as it heads into Birmingham in cutting.

5.2 Temporary works

5.2.1 All contractors will be required to comply with the environmental management regime for the Proposed Scheme, which will include:

- Code of Construction Practice (CoCP); and
- Local Environmental Management Plans (LEMP).

5.2.2 The key requirements of the draft CoCP in relation to flood risk are:

- making appropriate use of the Environment Agency's flood warning service;
- preparing site specific flood risk management plans for temporary works at risk of flooding from river, surface water and groundwater sources;
- considering flood risk when planning temporary sites and storing materials;

- obtaining consent, as required, for works affecting a watercourse;
- removing or stopping and sealing of drains and sewers taken out of use;
- not discharging site run-off to ditches, watercourses, drains or soakaways without agreement of the appropriate authority;
- ensuring hoarding and fencing in areas at risk of flooding is permeable to floodwater, unless otherwise agreed with the Environment Agency or Warwickshire County Council (the Local Lead Flood Authority in this study area); and
- implementing precautions to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

5.2.3 The temporary works will include both main and satellite construction compounds. These construction compounds will be utilised for office accommodation, local storage for plant and materials, car parking, material processing facilities and welfare facilities.

5.2.4 Areas adjacent to these construction compounds may be used for temporary storage of topsoil stripped as part of the works.

5.2.5 Temporary worker accommodation will also be required for construction of the Proposed Scheme.

6 Existing flood risk

6.1.1 The Environment Agency historical flood maps do not indicate any areas of historical flooding that will be either crossed by the route or will be within 1km of the route centreline.

6.1.2 The Warwickshire SFRA[9] historical flood maps indicate that there have been no incidents of flooding either at the location of the route or within 1km of the route centreline. This includes flood events from rivers, surface water, artificial sources, canals or unknown sources.

6.1.3 The Warwickshire PFRA[10] has also been used to identify potential locations of flooding in the vicinity of the route; however this mapping does not show any incidents of historical flooding at the location of the route. The PFRA mapping indicates that three locations of historical flooding occurred in the northern area of CFA19. None of the three locations identified in the PFRA mapping are indentified to flood regularly.

6.2 River flooding

6.2.1 River flood risk is the risk of flooding posed by rivers and streams. The risk in CFA19 is from the River Cole and its tributaries, and the River Tame at the northern extent of the study area. The areas at risk of flooding from this source are shown in Volume5: Map Book – Water resources, Maps WR-05 and WR-06.

6.2.2 The assessment of baseline (current) flood risk involved identifying watercourse crossings and the associated risk through the use of the Environment Agency Flood Zones. The results of this assessment are provided in Table 2. The watercourse identifier references have been taken from Volume5: Map Book – Water resources, Map WR-01-032. The River Tame viaducts, as listed in Table 2, are the River Tame east and west viaducts and the Water Orton no. 2 viaduct.

Table 2: Coleshill Junction river flood risk

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) + climate change flow	Risk level	Receptor vulnerability
SWC-CFA19-003 Volume5: Map Book – Water resources, Map WR-01-032, G5	Coleshill West viaduct and Coleshill East viaduct	Ordinary watercourse (River Cole tributary)	0.15m^3/s	Very high	Less vulnerable
SWC-CFA19-004 Volume5: Map Book – Water resources, Map WR-01-032, G5	Coleshill West viaduct and Coleshill East viaduct	Ordinary watercourse (River Cole tributary)	0.46m^3/s	Very high	Less vulnerable
SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-01-032, F6	Not crossed by the route. Coleshill West viaduct	Floodplain of the River Cole	-	Medium	Less vulnerable
SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-01-032, F6	River Cole West viaduct	Main river (River Cole)	88.93m^3/s	Very high	Less vulnerable

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) + climate change flow	Risk level	Receptor vulnerability
SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-01-032, F6	River Cole East viaduct	Main river (River Cole)	88.93m^3/s	Very high	Less vulnerable
SWC-CFA19-006 Volume5: Map Book – Water resources, Map WR-01-032, F5	M42 Coleshill south viaduct	Main river (River Cole)	88.41m^3/s	Very high	Less vulnerable
SWC-CFA19-010 Volume5: Map Book – Water resources, Map WR-01-032, E6	Coleshill culvert	Ordinary watercourse (River Cole tributary)	0.42m^3/s	Very high	Less vulnerable
SWC-CFA19-019 Volume5: Map Book – Water resources, Map WR-01-032, D6	Water Orton culvert	Ordinary watercourse (River Tame tributary)	0.47m^3/s	Very high	Less vulnerable
SWC-CFA19-013 Volume5: Map Book – Water resources, Map WR-01-032, C5	Not crossed by the route. Lichfield Road to the River Tame	Floodplain of the River Tame	-	High	Less vulnerable
SWC-CFA19-013 Volume5: Map Book – Water resources, Map WR-01-032, C5	River Tame viaducts	Main river (River Tame)	210.74m^3/s	Very high	Less vulnerable

6.2.3 The Environment Agency Flood Zone mapping indicates three main areas at risk from flooding:

- to the south of Birmingham Road at the location of the River Cole tributary crossing (Volume5: Map Book – Water resources, Map WR-01-032, F6);
- the River Cole crossings (Volume5: Map Book – Water resources, Map WR-01-032, F6); and
- the River Tame crossings (Volume5: Map Book – Water resources, Map WR-01-032, C5) at the northern extent of the study area.

6.2.4 The crossing locations are identified to fall within Flood Zone 3, however given that the route crosses the watercourse, they will also be located within Flood Zone 3b (very high risk).

6.2.5 The Environment Agency flood mapping covers watercourses with catchments greater than 0.5km^2, and hence small catchments are often not represented. This includes ordinary watercourses crossed by the Proposed Scheme, including Coleshill culvert (Volume5: Map Book – Water resources, Map WR-01-032, E6) and Water Orton culvert (Volume5: Map Book – Water resources, Map WR-01-032, D6).

6.2.6 Hydraulic modelling was carried out to provide a more accurate representation of river flood risk along the route, specifically at locations where the route will cross a watercourse. The modelling provided flood extents for the 1 in 100 (1%) annual

probability events with a 20% allowance for climate change and for the 1 in 20 (5%) annual probability events. Flood levels were also determined for the 1 in 1000 (0.1%) annual probability events to ensure that the proposed track will not be at risk during this event. The flood extents and levels as determined through hydraulic modelling are further detailed in the river modelling report (Volume 5, WR-004-012).

6.2.7 The Environment Agency Flood Zone mapping indicates that the ordinary watercourses crossed at Coleshill culvert and Water Orton culvert are located within Flood Zone 1, however following hydraulic modelling completed for this assessment it is redefined as Flood Zone 3b. Therefore the risk classification given to these locations is very high.

6.2.8 At the northern extent of the Coleshill West viaduct, a section of the route crosses an area categorised as at a medium risk of river flooding. This is owing to its location in the Environment Agency Flood Zone 2.

6.2.9 The Proposed Scheme at the northern boundary of this study area is located in an area at risk of river flooding from the River Tame. This includes a section of the route which will not cross a watercourse. This area is located within the Environment Agency Flood Zone 3 and hence has been categorised as at a high risk of river flooding.

6.2.10 The vulnerability classification as shown in Table 2 above has been taken from the NPPF and relates to the vulnerability of existing development in areas currently at risk from river flooding. In the vicinity of Birmingham Road, there are a number of properties located at risk of river flooding, of which one includes overnight accommodation. However, the Proposed Scheme involves demolition of this building and therefore less vulnerable development will be the only land use at risk. In the vicinity of the River Tame viaducts the vulnerability classification of less vulnerable has been assigned; this is owing to the sewage treatment works (and associated infrastructure) being at risk of flooding in this location. Elsewhere, in line with the NPPF, a less vulnerable classification has been given, because the land at risk is utilised for agricultural purposes (land and buildings used for agriculture and forestry).

6.2.11 The other locations along the route not identified in Table 2 are considered to be at either a low risk or no risk of river flooding.

6.3 Surface water/overland flow

6.3.1 This section is an examination of the existing flood risk posed by rainfall falling on the ground surface, referred to as surface water flooding. It is examined in terms of the water flowing over the ground surface that has not entered a natural drainage channel or artificial drainage system.

6.3.2 The areas at risk from surface water flooding are shown on map Volume5: Map Book – Water resources, Map WR-01-032. Table 3 details the risk to the development from this source of flooding.

Table 3: Coleshill Junction sources of surface water flooding

Description of surface water flooding location	Description of possible influence to the Proposed Scheme	Risk
In the vicinity of the M6 Motorway north viaduct and tributaries of the River Cole Volume5: Map Book – Water resources, Map WR-01-032, H5	An area susceptible to surface water flooding will be crossed by the route at the location of the M6 and adjacent to a tributary of the River Cole. There are also areas to the east and west of the route and within 1km of the route centreline, which are at risk. The areas are at a high, medium and low risk.	High
In the vicinity of the B4114 crossing and the River Cole to the west of the Proposed Scheme. Volume5: Map Book – Water resources, Map WR-01-032, G5	An area susceptible to surface water flooding will be crossed by the route at this location. To the west of the route is the River Cole and a high risk is associated with this watercourse. Elsewhere along this section, the route will cross areas predominately at a low and medium risk, although an isolated area of high risk is located to the north of Coleshill Hall Farm.	High
At the location of the River Cole crossings including the M42 Coleshill south viaduct and the River Cole west viaduct Volume5: Map Book – Water resources, Map WR-01-032, F5	The route will cross the River Cole which is classed at high risk from surface water flooding. Elsewhere along this section and within 1km of the route centreline, are areas at medium and low risk of surface water flooding.	High
Gilson settlement Volume5: Map Book – Water resources, Map WR-01-032, E5	Areas susceptible to surface water flooding are located to the east and west of the route within 1km of the route centreline. To the west these areas are categorised at predominately high risk. To the east these areas are at a medium and low risk.	High
Chattle Hill Volume5: Map Book – Water resources, Map WR-01-032, E5	An isolated area at a high risk from surface water flooding will be crossed by the route at this location.	High
Litchfield Road crossing (Chattle Hill box structure) Volume5: Map Book – Water resources, Map WR-01-032, D5	Several isolated areas at a medium and low risk will be crossed by the route at this location.	Medium
Areas to the north of Litchfield Road crossing and the River Tame Volume5: Map Book – Water resources, Map WR-01-032, C5	Areas at high, medium and low risk of surface water flooding are located to the east and west of the route.	High

6.3.3 There are seven locations along the route in this study area which have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. At the majority of these locations the risk of surface water flooding ranges from low to high, however as a conservative approach the highest level of risk has been assigned. Therefore at six locations the risk is considered high and at one location the risk is considered medium.

6.3.4 In line with the risk category matrix provided in Table 1, and the data available for this FRA, all other locations along the route within this study area are classed to be at no risk from surface water flooding.

6.4 Groundwater

6.4.1 Groundwater flood risk has been qualitatively assessed based on hazard identification and evaluation using the conceptual understanding of the ground conditions at the location of the Proposed Scheme. The assessment of the current groundwater flood risk is based on the presence or otherwise of an aquifer and the relative depth of groundwater level, as well as historical information on the occurrence of groundwater flooding incidents.

6.4.2 The bedrock underlying the study area is of Mercia Mudstone (mudstone of Triassic age) which is a Secondary aquifer. These are overlain by glacial clays, sands and gravel, with alluvium and river terrace gravels found within the river valleys. Sands and gravels, alluvium and river terrace gravels are also considered Secondary aquifers

6.4.3 Only very limited data on groundwater levels has been made available within the study area. However, it is considered that groundwater flow is likely to be towards watercourses and groundwater, especially within the alluvium, and that groundwater may be within 2m of ground level.

6.4.4 The SFRA and PFRA do not record any instances of groundwater flooding and therefore the risk is assessed as low.

6.5 Sewer systems

6.5.1 Sewer infrastructure is a potential source of flood risk in the event of a failure. Due to the nature of the closed sewer system, sewer flooding will only be caused if there is a blockage or a leak or if there is a rainfall event greater than the design capacity of the network.

6.5.2 The risk to the route from the sewer network has been determined based on the location of development in relation to the network and the proximity and potential flow paths from inspection covers. Flow paths have been assessed through the use of LiDAR and OS mapping. A summary of this assessment is included in Table 4. The approximate location where the route will cross the existing sewer network has been taken from maps CT-06-108b to 136a (Volume 2: CFA19, Map Book).

Table 4: Coleshill Junction sources of sewer network flooding

Location	Supplier	Comment	Risk
CT-06-108b, B5 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will cross the sewer network and there is an inspection cover at the location of the route. However the sewage pipes will be diverted under the railway north of the M6/M42 junction. If inspection covers are placed along this diversion, the location of these will be adjacent to track drainage and therefore it is assumed any surcharging at this location will be directed along the drainage path hence resulting in a restricted path way to the other elements of the works.	Medium
CT-06-109, E4 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will be located between 130 and 200m to the east of inspection covers. However the Proposed Scheme will involve a viaduct at this location and hence there will be no flow paths to the route.	No risk
CT-06-110, G6 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will be located on and within 50m of inspection covers. However the sewer networks will be diverted under the Birmingham spur to the west of the M42/River Cole crossing. The relocation will be to areas where a viaduct is proposed and hence there will be no flow path to the proposed track.	No risk

Location	Supplier	Comment	Risk
CT-06-110, E6 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will cross the sewer network and there is an inspection cover adjacent to the eastern boundary of the route. However the topography of the area would indicate a limited flow path to the works.	Medium
CT-06-110, D6 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will cross the sewer network and there is an inspection cover adjacent to the western boundary of the route. However the inspection cover is located in the area of proposed track drainage channels and it is assumed any surcharging at this location will be directed along the drainage path, hence resulting in a restricted flow path to the other elements of the works.	Medium
CT-06-110, B6 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will cross the sewer network, but there are no identified flow paths or surcharge points to the route. A sewerage diversion is proposed crossing under Lichfield Road.	Low
CT-06-111a, H4 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will be located within 60m of inspection covers. The topography of the area indicates potential flow routes to the route, however it is likely that flood flow will be dispersed by the mitigation planting and track drainage channel and hence resulting in a restricted path way to the other elements of the works.	Medium
CT-06-111a, E4 (Volume 2: CFA19, Map Book)	Severn Trent Water	The route will cross the sewer network and there is an inspection cover at the location of the route. The inspection cover is at the location of proposed track drainage channels and it is assumed any surcharging at this location will be directed along the drainage path, hence resulting in a restricted path way to the other elements of the works.	Medium
CT-06-134a, E6 (Volume 2: CFA19, Map Book)	Severn Trent Water	On the north chord, the route will cross the sewer network and there are inspection covers located within 20m of the proposed route. At this location it is anticipated that if surcharging occurred flood water will either travel along the road or enter the proposed drainage channels to be constructed as part of the scheme. Despite which potential flow path is used, there will be restricted flow paths to the route.	Medium

6.5.3 There are two locations where the route will cross the sewer network and in close proximity to inspection covers. However at these locations the route will be on a viaduct and hence there will be no possible flow paths to the route. Therefore at these locations a no risk category has been assigned.

6.5.4 The Proposed Scheme will cross the sewer network at one location where there are no inspection covers within close proximity to the route. Therefore at this location a low risk has been assigned.

6.5.5 At six locations in this study area the Proposed Scheme will cross the sewer network and inspection covers will be location on or in close proximity to the route. However at these locations, owing either to the topography of the area or propose drainage channels, any flow paths from the surcharge points to the route will be restricted. Therefore a medium risk category has been assigned.

6.6 Artificial sources

6.6.1 Artificial sources of flood risk describe a mechanism whereby flooding would be the result of failure of infrastructure that impounds water such as in a canal or reservoir.

6.6.2 The Proposed Scheme will not cross or will not be located in close proximity to any canals within this study area. Therefore there is no risk of flooding to the Proposed Scheme from this source.

6.6.3 There is one location in this study area identified to be at risk of reservoir flooding as shown on the Environment Agency reservoir inundation mapping. This area is along the River Tame and in surrounding areas, at the northern extent of this study area as shown on map WR-01-032, C5 (Volume5: Map Book – Water resources). The reservoir inundation mapping identifies that this area will be inundated if either Rotton Park (also known as Edgbaston Reservoir) or Bartley reservoirs fail. These reservoirs are located at least 15km upstream of the Proposed Scheme that it is considered that flood water would be of low velocity and likely to be a low hazard at the location of the works. In addition, the reservoir inundation extent is less than the widths of Flood Zone 2 and 3 and therefore the risk from reservoir flooding is considered lower than the risk of river flooding at this location.

6.6.4 Due to the strict regulations and high maintenance associated with reservoirs, breaching is considered unlikely. In line with the risk category matrix in Table 1 the risk of flooding from this source is considered low.

6.7 Summary

6.7.1 The Proposed Scheme includes eight watercourse crossings in this study area and therefore it is concluded that the Proposed Scheme will be within areas that are categorised at a very high risk from river flooding. The Proposed Scheme will also encroach into two areas at risk of river flooding without crossing watercourses at these locations. The only land uses at risk in this study area (which could be impacted as result of the Proposed Scheme) are classed as less vulnerable.

6.7.2 There are seven locations along the route which have been identified to be at risk from surface water flooding. The risk at these locations generally ranges from low to high, although as a conservative approach to highest level of risk has been assigned. Therefore six locations have been categorised as at a high risk and one location at a medium risk.

6.7.3 The risk presented by groundwater flooding is considered to be low.

6.7.4 The Proposed Scheme will cross and be located in close proximity to the sewer network nine times; however either owing to the topography of the area or the scheme design (viaducts, drainage channels and mitigation planting) any potential flow paths will be restricted. Therefore the highest level of risk to the Proposed Scheme from this source is categorised as medium.

6.7.5 The Proposed Scheme does not cross any canals in this study area and hence there is no risk of flooding from this source. Due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the Proposed Scheme is considered low.

7 Flood risk management measures

7.1 River flood risk

Flood risk to proposed scheme

7.1.1 The Proposed Scheme will be raised above the 1 in 1000 (0.1%) annual probability flood level at floodplain crossings. Therefore, the mitigation measures included in the design have ensured that there are no instances where the Proposed Scheme would be at significant risk of river flooding, and consequently no specific mitigation is required.

Impact of proposed scheme

7.1.2 At all floodplain crossings, replacement floodplain storage would be provided upstream of the Proposed Scheme for losses in floodplain storage, including viaduct piers, embankments and all associated development.

River Cole west and east viaducts

7.1.3 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 349mm, extending to a maximum distance of 1.1km upstream of the River Cole west and east viaducts during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a major impact which will be reduced through the incorporation of replacement floodplain storage.

M42 Coleshill south viaduct

7.1.4 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 226mm, extending to a maximum distance of 1.8km upstream of the M42 Coleshill south viaduct during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a major impact which will be reduced through the incorporation of replacement floodplain storage.

Other watercourse crossings

7.1.5 The hydraulic modelling for the other six watercourse crossings in this study has shown that the Proposed Scheme will have a negligible impact on river flood risk. Areas of land have been identified as suitable to provide replacement floodplain storage, therefore reducing the impact. Any replacement floodplain storage at the locations of negligible impact is likely to provide betterment.

Mitigation for temporary works

7.1.6 The temporary works have the potential to result in an increased river flood risk and be at risk of flooding from this source. The proposed mitigation and measures to prevent an unacceptable risk of river flooding for the temporary works includes signing up to the Environment Agency flood warning system for the " River Cole – Low-lying land and roads between Majors Green and Coleshill on the River Cole" for works in close proximity to the River Cole; and the "Upper Tame – Low-lying land and roads between Horseley Heath and Castle Vale on the River Tame and Bescot on the Ford Brook" for works in the north of this study area. Any temporary crossings will be designed to prevent an increased flood risk through ensuring sufficient capacity

during the 1 in 100 (1%) annual probability event; an indication of the flows which will be considered are included in Table 2.

7.2 Surface water flood risk

Flood risk to Proposed Scheme

7.2.1 In this study area, the areas categorised as being at a high risk of surface water flooding are generally associated with the watercourses identified in the river flooding sections in this report. At these locations the scheme design will ensure that the track is situated above the 1 in 1000 (0.1%) annual probability event flood level with a 1m freeboard. Therefore as long as there is no blockage of these structures, a low surface water flood risk to the track is anticipated at these locations.

7.2.2 At the one location, where the route potentially crosses surface water flow paths, water will be collected and diverted under the route adjacent to the M6 Motorway north viaduct. Therefore, as long as the collection systems and surface water culverts are designed with sufficient capacity, there should be no backing up, and no expected risk of flooding to the Proposed Scheme.

Impact of Proposed Scheme

7.2.3 Potential increases in peak discharge rates of surface water run-off will be attenuated prior to discharging to the receiving watercourse. Any additional surface water to be discharged will be at a trickle rate to prevent exceeding the current capacity of the receiving watercourse.

7.3 Risk of flooding from groundwater

Flood risk to Proposed Scheme

7.3.1 The risk from groundwater flooding to the Proposed Scheme has been assessed as low and therefore no specific management measures are considered necessary.

Impact of the Proposed Scheme

7.3.2 The Proposed Scheme is no anticipated to have an impact on groundwater flooding and therefore no specific management is considered necessary.

7.4 Risk of flooding from sewer systems

7.4.1 There will be a medium risk of flooding from sewer systems to the Proposed Scheme, and there are no anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific mitigation would be required.

7.5 Risk of flooding from artificial sources

Flood risk to Proposed Scheme

7.5.1 There are no instances where the Proposed Scheme would be at significant risk of flooding from artificial sources, and consequently no specific mitigation is required.

Impact of the Proposed Scheme

7.5.2 The Proposed Scheme in this study area is at risk of flooding resulting from the complete failure of four reservoirs. However, the replacement floodplain storage provided to mitigate the potential effects of river flooding would serve to either fully or partially offset any potential effects of the Proposed Scheme on flooding from this source. Due to the low probability of such flooding occurring, and the likely low significance of any impacts arising from the Proposed Scheme, it is not considered appropriate to provide additional mitigation for this scenario.

8 Post development flood risk assessment

8.1 River flooding

8.1.1 The key design elements of the Proposed Scheme with potential flood risk considerations have been modelled for this FRA. The river modelling methodology and results specific for each watercourse crossing are included in the river modelling report (Volume 5, WR-004-012). A summary of the results are presented in Table 5. The watercourse identifier references have been taken from map WR-01-032 (Volume5: Map Book – Water resources).

Table 5: Coleshill Junction river flood risk

Watercourse identifier and map reference	Crossing name	1 in 100 (1%) + climate change flow	Change in flood level 1 in 100 (1%) + climate change	Change in flood level 1 in 1000 (0.1%)	Proposed Scheme 1 in 1000 (0.1%) level	Length of impacted upstream reach[19]
SWC-CFA19-003 Volume5: Map Book – Water resources, Map WR-05-054, C6	Coleshill West viaduct and Coleshill East viaduct	0.15m^3/s	0mm	7mm	80.233m AOD	0m
SWC-CFA19-004 Volume5: Map Book – Water resources, Map WR-05-055, I5	Coleshill West viaduct and Coleshill East viaduct	0.46m^3/s	0mm	9mm	80.199m AOD	0m
SWC-CFA19-005 WR-05-055, G6 Volume5: Map Book – Water resources, Map	River Cole west viaduct	88.93m^3/s	349mm	520mm	77.833m AOD	1,117m
SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-05-055, G6	River Cole east viaduct	88.93m^3/s	349mm	520mm	77.833m AOD	1,117m
SWC-CFA19-006 Volume5: Map Book – Water resources, Map WR-05-055, G5	M42 Coleshill south viaduct	88.41m^3/s	226mm	216mm	77.160m AOD	1,835m
SWC-CFA19-010 Volume5: Map Book – Water resources, Map WR-05-055, E8	Coleshill culvert	0.42m^3/s	0mm	0mm	84.382m AOD	0m

[19] Length of reach upstream of the Proposed Scheme along which flood levels during the 1 in 100 (1%) annual probability+ climate change are greater than 10mm.

Watercourse identifier and map reference	Crossing name	1 in 100 (1%) + climate change flow	Change in flood level 1 in 100 (1%) + climate change	Change in flood level 1 in 1000 (0.1%)	Proposed Scheme 1 in 1000 (0.1%) level	Length of impacted upstream reach[19]
SWC-CFA19-019 Volume5: Map Book – Water resources, Map WR-05-055, C7	Water Orton culvert	0.47m^3/s	0mm	0mm	80.714m AOD	0m
SWC-CFA19-013 Volume5: Map Book – Water resources, Map WR-05-055, A5	River Tame viaducts	210.74m^3/s	0mm	0mm	75.543m AOD	0m

8.1.2 One hydraulic model was used to determine the combined impacts of the River Cole crossings, the proposed diversion of Manor Drive and the River Cole realignment. This area is shown in maps WR-05-055, F5, G5 and G6 (Volume5: Map Book – Water resources). The hydraulic modelling indicates that without mitigation there is a major increase in flood levels at the River Cole west and east viaducts and the M42 Coleshill south viaduct, as shown Table 5. These changes in flood level are the result of the significant constriction on flow caused by the River Cole west and east viaducts and the development in the floodplain at this location. However the hydraulic modelling has shown that the replacement floodplain storage, upstream of Manor Drive and at the location between the M42 Coleshill south viaduct and River Cole east viaduct, will reduce the impact on flood level to a minor impact. The area along this reach of the River Cole is surrounded by less vulnerable land uses and hence no vulnerable development will be at risk if the Proposed Scheme does result in a minor increase in flood level.

8.1.3 As shown in Table 5, the hydraulic modelling completed for the other watercourse crossings in this study area demonstrated that the change in flood level as a result of the Proposed Scheme is negligible.

8.1.4 Watercourses pose a river flood risk to the other design elements in this study area. The areas at risk from river flooding are shown on maps WR-05-054, 055 and 066 and WR-06-054, 055 and 066 (Volume5: Map Book – Water resources), which are based on the hydraulic modelling results rather than Environment Agency Flood Zone mapping. The river flood risks to these works are included in Table 6.

Table 6: River flood risks to the other design elements

Works at risk	Watercourse identifier and map reference	Location description	Description of the works and flood risk	Risk
Earthworks Landscaping Other	SWC-CFA19-002 Volume5: Map Book – Water resources, Map WR-05-054, D6	M6 Motorway north viaduct	The ordinary watercourse will be diverted around the proposed track embankments. The other works in this area at risk will be landscaping. There are no Environment Agency Flood Zones associated with this watercourse and hydraulic modelling has not been completed at this location. Works are required on the banks of the watercourse and hence a high risk has been categorised.	High

Works at risk	Watercourse identifier and map reference	Location description	Description of the works and flood risk	Risk
Highways Earthworks Landscaping	SWC-CFA19-003 and 004 Volume5: Map Book – Water resources, Map WR-05-054, C6 and B5	In the vicinity of the Coleshill west viaduct	Proposed landscaping, earthworks and an access track will be located in areas at risk during the 1 in 20 (5%) annual probability event.	Very high
Highways Earthworks Landscaping	SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-05-055, G6	In the vicinity of the River Cole west viaduct	The realignment of Manor Drive will include works in the River Cole floodplain and an overbridge across this watercourse. The works in this area will also include landscaping and earthworks. The work at this location will also include the realignment of the River Cole. The works are located in areas at risk during the 1 in 20 (5%) annual probability event.	Very high
Landscaping Earthworks Highways	SWC-CFA19-007 Volume5: Map Book – Water resources, Map WR-05-055, E5	In the vicinity of the Gilson Road realignment	Landscaping will cross a tributary of the River Cole to the west of the route. There is no associated Flood Zone with this watercourse. The realignment of Gilson Road, and associated earthworks, will include a culvert to maintain flow along a tributary of the River Cole. Owing to the proposed scheme crossing a watercourse a very high risk has been assigned.	Very high
Earthworks Landscaping	SWC-CFA19-019 Volume5: Map Book – Water resources, Map WR-05-055, C7	On the north chord	Proposed works will cross a tributary of the River Tame at the location of the North Chord. The works in this area at risk from flooding involve landscaping and earthworks. Owing to the proposed scheme crossing a watercourse a very high risk has been assigned.	Very high
Earthworks Landscaping	SWC-CFA19-010 Volume5: Map Book – Water resources, Map WR-05-055, E8	On the Birmingham spur	Proposed works will cross a tributary of the River Cole at the location of the Birmingham Spur. The works in this area at risk from flooding involve landscaping and earthworks. Owing to the proposed scheme crossing a watercourse a very high risk has been assigned.	Very high

8.1.5 The Proposed Scheme involves the diversion of four watercourses in this study area. The realignment of the River Cole has been included in the hydraulic modelling discussed earlier in this section. The hydraulic modelling includes the proposed overbridges and viaduct piers, which cause a minor increase in flood levels downstream of the crossing. This is through the construction of replacement floodplain storage upstream of Manor Drive and at the location between the M42 Coleshill south viaduct and River Cole east viaduct. The detailed design of the channel realignment will reduce this increase in flood level to a negligible impact.

8.1.6 In addition to the realignment of the River Cole, the smaller watercourses that will be culverted will also be altered slightly as a result of straightening required for the culverts. The watercourse diversion at these locations is minor and will have a negligible impact on river flood risk.

8.1.7 The proposed realignment of Manor Drive involves a bridge over the River Cole which has been included in the hydraulic modelling. The existing bridge at this location acts a constriction to flow within the watercourse. The proposed bridge has a higher capacity for flow due to the three flood relief culverts proposed along the Manor Drive

diversion. The proposed replacement floodplain storage upstream of this road crossing will further reduce the impact of the Proposed Scheme on river flood risk, resulting in a negligible change in water level.

8.1.8 The Proposed Scheme involves the realignment of Gilson Road which requires a culvert for a minor tributary of the River Cole. This watercourse is not culverted at present. In line with the design criteria outlined in Section 2.6.23 of this report, the culvert will be designed to have sufficient capacity for the 1 in 100 (1%) annual probability flow with an allowance for climate change and the appropriate freeboards as outlined in Section 2.6.23.

8.1.9 In addition to the road culverts outlined in Table 6, there are other culverts proposed in this study area. However these culverts are required for the surface water drainage system which forms part of the Proposed Works, rather than for existing watercourses. The capacity requirements for these culverts are addressed as part of the drainage design.

8.1.10 Temporary works as required for the construction phase are also located in areas at risk from river flooding. The temporary works at risk are listed in Table 7.

Table 7: River flood risk to temporary works

Watercourse identifier and map reference	Receptor	Comment	Risk
SWC-CFA19-002 Volume5: Map Book – Water resources, Map WR-05-054, D6	Ordinary watercourse (River Cole tributary)	The Birmingham spur diveunder compound will be located adjacent to the proposed realignment of the watercourse at this location. The temporary works will also involve an access track/haul road, a temporary plant crossing and fencing over this watercourse.	Very high
SWC-CFA19-003 and 004 Volume5: Map Book – Water resources, Map WR-05-054, C6 and B5	Ordinary watercourses (River Cole tributaries)	The temporary works will involve an access track/haul road, a temporary plant crossing and fencing over this watercourse.	Very high
SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-05-055, G6	Floodplain of the River Cole	The temporary works will involve an access track/haul road, demolition sites and fencing.	High
SWC-CFA19-005 Volume5: Map Book – Water resources, Map WR-05-055, G6	Main river (River Cole)	The temporary works will involve an access track/haul road, a temporary plant crossing and fencing over this watercourse.	Very high
SWC-CFA19-006 Volume5: Map Book – Water resources, Map WR-05-055, F5	Main river (River Cole)	The temporary works will involve an access track/haul road and fencing adjacent to this watercourse.	High
SWC-CFA19-010 Volume5: Map Book – Water resources, Map WR-05-055, E8	Ordinary watercourse (River Cole tributary)	The temporary works will involve an access track/haul road, a temporary plant crossing and fencing over this watercourse.	Very high
SWC-CFA17-019 Volume5: Map Book – Water resources, Map WR-05-055, C7	Ordinary watercourse (River Tame tributary)	The temporary works will involve an access track/haul road and a temporary plant crossing over this watercourse.	Very high

Watercourse identifier and map reference	Receptor	Comment	Risk
SWC-CFA19-013 Volume5: Map Book – Water resources, Map WR-05-055, A5	Floodplain of the River Tame	The temporary works will involve an access track/haul road and fencing adjacent to this watercourse.	High
SWC-CFA19-013 Volume5: Map Book – Water resources, Map WR-05-055, A5	Main river (River Tame)	The temporary works will involve an access track/haul road, a temporary plant crossing and fencing over this watercourse.	Very high

8.1.11 There are nine locations of temporary works that are located in areas at risk from river flooding. The areas at risk have been identified through the hydraulic modelling completed for this assessment.

8.1.12 Hydraulic modelling is not considered necessary for the temporary works because the works will be constructed in line with the CoCP (Section 16.3 of the draft CoCP) and thus the design will consider river flood risk. Therefore temporary works will not result in an increased flood risk to any existing receptors.

8.1.13 The hoarding and fencing around a site for security purposes has the potential to alter flow paths and thus impact on flood risk at the three locations identified in Table 7. However the hoarding and fencing in areas at risk of flooding will be permeable to floodwater, (as outline in the design criteria in Section 2.6.23 of this report), unless otherwise discussed with the Environment Agency or Local Lead Flood Authority. This will ensure that the floodplain continues to function effectively for storage and conveyance of floodwater.

8.1.14 The temporary works other than those outlined in Table 7 are considered to be at a low risk of river flooding.

8.2 Surface water/overland flow

8.2.1 The proposed track will result in increased run-off rates due to a reduction in infiltration capacity. Therefore the entire length of the track may be at risk from this source and could increase risk elsewhere.

8.2.2 In addition the track drainage has the potential to increase flood risk in receiving watercourses if not attenuated. In this study area there are nine proposed balancing ponds, these are located as follows:

- to the east of the M6 Motorway south viaduct (Volume 2: CFA19, Map Book, Map CT-06-108b, E5);
- to the south of Coleshill west viaduct (Volume 2: CFA19, Map Book, MapCT-06-109, G6);
- to the east of the Manor Drive realignment (Volume 2: CFA19, Map Book, MapCT-06-109, B5);
- to the south of the Gilson Road realignment (Volume 2: CFA19, Map Book, MapCT-06-110, E5);
- to the west of the Chattle Hill box structure (Volume 2: CFA19, Map Book,

MapCT-06-111a, F5);

- to the north of the Water Orton No.3 viaduct (Volume 2: CFA19, Map Book, MapCT-06-111a, D5);
- to the west of the River Cole West Viaduct (Volume 2: CFA19, Map Book, MapCT-06-110, I8); and
- two to the north of the north chord (Volume 2: CFA19, Map Book, MapCT-06-134a, E5 and I3).

8.2.3 The outfall from these balancing ponds will be attenuated as described in Volume 1, Section 9 to ensure that run-off rates are not increased above existing levels to prevent an increase in risk.

8.2.4 The route has the potential to interrupt surface water movement, which could result in an increase in surface water flood risk. The Environment Agency FMfSW indicates that the Proposed Scheme will interrupt one overland flow path in this study area.

8.2.5 To the north of the M6/M42 junction there is an overland flow path not associated with a watercourse (located on Volume 5: Map Book – Water resources, Map WR-01-032, G5). However overland flow to the north west of the route at this location will flow in a westerly direction and discharge to the River Cole as existing. Overland flow to the south east will be collected and diverted under the route adjacent to the M6 Motorway north viaduct. Therefore there will no significant interruption of surface water movement and hence associated increase in flood risk at this location.

8.2.6 The potential impact of the Proposed Scheme on surface water movement, additional to the above, will be incorporated within the scheme design. Therefore the works will have no impact on surface water flood risk.

8.2.7 There are other design elements of the Proposed Scheme which will be at risk from surface water flooding. The surface flood risks to the other design elements, as identified from the Environment Agency FMfSW are included in Table 8.

Table 8: Surface water flood risks to other design elements of the Proposed Scheme

Works at risk	**Location description**	**Description of possible influence to the Proposed Scheme**	**Risk**
Highways Earthworks Landscaping	East of Chelmsley Wood Volume5: Map Book – Water resources, Map WR-01-032, H5	A proposed footpath, earthworks and landscaping will be located partly in an area susceptible to surface water flooding, with a medium and low risk of flooding. The area is associated with a watercourse.	Medium
Highways	Manor Drive Volume5: Map Book – Water resources, Map WR-01-032, G5	The road diversion will be located in areas at low to high risk of surface water flooding. This road realignment will cross the River Cole and hence has been discussed in detail in the river flood risk section of this FRA. The other design elements that will be at risk include earthworks, landscaping and a new footpath. These works will be primarily located in areas classed as being as a low and medium risk, with small areas categorised as being at a high risk.	High
Highways	Gilson Road Volume5: Map Book – Water resources, Map WR-01-032, E5	The road diversion will be located in areas at low to high risk of surface water flooding.	High

Works at risk	Location description	Description of possible influence to the Proposed Scheme	Risk
Earthworks Landscaping	Between the area to the south of Chattle Hill box structure and the northern boundary of this study area Volume5: Map Book – Water resources, Map WR-01-032, C5 and D5	The Chattle Hill box structure, earthworks and landscaping will be located in areas categorised as being at low, medium and high risk of surface water flooding.	High
Earthworks Landscaping	north chord Volume5: Map Book – Water resources, Map WR-01-032, D7	The landscape and earthworks will cross isolated areas susceptible to surface water flooding. The areas are categorised to be at low, medium and high risk.	High

8.2.8 There are five locations where other design elements are located in areas susceptible to surface water flooding. In general, these areas range from low to high risk and as a conservative approach the highest level of risk has been assigned. Therefore, four of the five locations are categorised as being at a high risk and one being at a medium risk of surface water flooding.

8.2.9 The other design elements not listed in Table 8 are considered to be at no risk from surface water flooding in line with the flood risk category matrix.

8.2.10 All other design elements, including those not listed in Table 8, have the potential to increase surface water run-off rates through reduced infiltration capacity. The design for the Proposed Scheme includes surface water run-off management (such as drainage channels and balancing ponds) to prevent an increased risk of flooding from this source both on site and in neighbouring areas.

8.2.11 Table 9 details the risk to the temporary design elements from surface water flooding.

Table 9: Sources of surface water flooding to temporary works

Description of surface water flooding location	Description of possible influence on temporary design elements	Risk
East of Chelmsley Wood Volume5: Map Book – Water resources, Map WR-01-032, G5 and H5	Sector 5 Coleshill Heath Road Compound, and the M6 motorway north (south) satellite compound will be located party in an area at risk. A temporary bridge also crosses an area at risk. This is not associated with a watercourse. The risk in this area is categorised as low and medium.	Medium
East of Chelmsley Wood Volume5: Map Book – Water resources, Map WR-01-032, G5	Temporary bridges and two demolition sites will be within areas at risk. The risk in this area is categorised as low and medium.	Medium
Coleshill Volume5: Map Book – Water resources, Map WR-01-032, D5 and E5	Various temporary works located in this area will cross isolated areas at risk from surface water flooding. These isolated areas are small and classed as at low and medium risk.	Medium

8.2.12 There are three locations where temporary design elements in this study area have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. A conservative approach has been taken in categorising risk as outlined earlier in this section. Therefore, in line with the flood risk category matrix (Table 1) a medium risk has been categorised at all locations in this study area.

8.2.13 Construction compounds have the potential to interrupt overland surface water flow paths. However, there are no compounds in this study area that will interrupt surface water flow paths which are identified on the Environment Agency FMfSW.

8.2.14 In line with the risk category matrix provided in Table 1, all other locations for temporary works within this study area are classed to be at no risk from surface water flooding.

8.2.15 The works will be completed in line with the CoCP (Section 16 of the draft CoCP) and hence the design of the temporary works will prevent an unacceptable level of surface water flood risk on site.

8.2.16 Temporary works not identified to be at risk on the FMfSW also have the potential to increase flood risk from this source in neighbouring areas as a result of reduced ground permeability. Therefore, in line with the CoCP (Section 16 of the draft CoCP), surface water will be managed at all locations of temporary works, including areas not identified to be at risk from surface water in Table 9. This will ensure that the temporary works are at an acceptable level of risk and will not cause an increased risk elsewhere from surface water flooding.

8.3 Groundwater

8.3.1 Developments may increase the risk of groundwater flooding where a barrier to groundwater flow in constructed across the natural flow path. The presence of such a barrier may impede groundwater flow causing levels to increase up gradient; if these levels rise to the ground surface groundwater flooding may occur.

8.3.2 A review of the Proposed Scheme in this study area does not indicate that any barriers to flow will be introduced that will affect a significant aquifer thickness.

8.3.3 It is therefore concluded that the scheme will not increase the risk of groundwater flooding.

8.4 Sewer systems

8.4.1 There are nine locations in this study area where the route will cross the sewer network or where surcharge points are located in close proximity to the Proposed Scheme. The flood risk from these areas range from no risk to a medium risk.

8.4.2 Six of these nine locations along the route have been identified to be at a medium risk of flooding from this source because surcharge points are located within 20m of the route but there are limited flow paths. At one location this is because of surrounding topography, and at five locations this is because the Proposed Scheme includes drainage channels (for the purposes of track drainage requirements). At four of these five locations, water entering the drainage channel will be diverted into a similar location as it is currently and there will be no impact on vulnerable land uses. At one of the five locations the surcharging water will either travel to the same location as at present, or it will enter the proposed drainage channel before entering a balancing pond.

8.4.3 The potential risk from this source of flooding has been considered in relation to the other design elements. The other design elements at risk include landscaping

earthworks, however any surcharging at these locations will enter drainage channels or flow away from the works, and hence the highest level of risk categorised is medium.

8.4.4 The diversion of Gilson Road crosses the sewerage network and there are inspection covers located within 20m of its proposed realignment. If surcharging occurs from the inspection covers to the east, then flood water will flow in the same direction as at present. If surcharging occurs on the western site, flood water is likely to either flow into the proposed track drainage or along the boundary of the road and in the same direction as existing. The track will be located on the M42 Coleshill north viaduct at this location and hence there is no risk to the proposed track. Given the restricted flow path to the road realignment a medium risk has been assigned at this location.

8.4.5 In the this study area there are numerous locations in which the sewer network crosses temporary design elements, specifically vegetation clearance areas, demolition areas, worksites and an access road. Due to the nature of the closed sewer system the risk of flooding from sewers is relatively low. However there are several locations where the temporary development is located either at or in close proximity to inspection covers and potential flow paths are present; therefore a high risk has been assigned.

8.4.6 The Proposed Scheme will involve the diversion of seven large diameter foul sewers. The diversion of the sewer network will involve locating inspection covers, and hence surcharge points, where these are not currently present. However these are not anticipated to cause a risk to vulnerable land uses. Once constructed, there will be no flow paths between the sewers and the Proposed Scheme and hence the risk is considered low. There is potential risk during the construction phase; however, this risk will be managed through completing the works in line with the CoCP.

8.4.7 The works will be completed in line with the CoCP and hence will ensure that the Proposed Scheme and neighbouring areas will not be at an increased flood risk from this source. One such measure outlined in the draft CoCP requires the removal or stopping and sealing of drains and sewers taken out of use. Similarly as outlined in the draft CoCP, precautions will also be taken to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

8.5 Artificial sources

8.5.1 At locations where the route will cross canals or areas at risk of flooding as a result of reservoir failure, there is potential that the Proposed Scheme may either increase risk from this source, or divert flood water causing new areas to be put at risk.

Reservoirs

8.5.2 In this study area the Proposed Scheme, in the vicinity to the River Tame crossing (WR-05-055, A5, Volume5: Map Book – Water resources, Map) is at risk of flooding should either Rotton Park (Edgbaston) or Bartley reservoirs fail. The temporary works, specifically landscaping, a proposed access road and temporary fencing, would also be at risk should these reservoirs fail. These reservoirs are located a significant distance upstream of the Proposed Scheme and the reservoir inundation extent is less than the widths of Flood Zone 2 and 3 and hence it is considered that the flood risk will not be no worse than the river flood risk. Furthermore the vertical clearance required for river

flooding on this watercourse will be sufficient to prevent significant alteration of flood water flow paths and inundation during reservoir flooding.

8.5.3 In line with the risk category matrix (Table 1) the flood risk to all elements of the Proposed Scheme from reservoir failure is considered low.

8.5.4 The draft CoCP outlines that areas at risk of flooding should be considered when planning sites and storing materials. Although the flood risk areas are likely to be taken from the river flood risk maps, at the location at risk from reservoir inundation in this study area, the reservoir inundation maps are smaller than the areas at risk from river flooding. Therefore it is considered that the temporary works will not significantly alter flood flow paths and hence alter flood risk from this source to other receptors.

8.5.5 There are no other locations within this study area that are at risk of flooding from reservoir failure as shown on the Environment Agency reservoir inundation maps. It is therefore concluded that the Proposed Scheme, including the route, other design elements and temporary works, will be at a low risk of flooding from this source (Table 1) and will not result in an increased risk elsewhere.

Canals

8.5.6 The Proposed Scheme will not cross or will not be located in close proximity to any canals within this study area. Therefore there is no risk of flooding to the Proposed Scheme from this source.

8.6 Summary

8.6.1 The Proposed Scheme will be located in areas at risk from river flooding, including at eight watercourse crossings where a very high risk has been assigned. However the hydraulic modelling completed at these eight locations identifies that at six of the crossings the impact of the Proposed Scheme is negligible. At one location the Proposed Scheme would have a major impact on river flood risk, this would be due to the combined impact of the River Cole west and east viaducts and the M42 Coleshill south viaduct. However through the construction of replacement floodplain storage this change is reduced to a minor impact and therefore a slight effect.

8.6.2 The Proposed Scheme will cross areas susceptible to surface water flooding. In general, at each of the areas the risk ranges from low to high, although as a conservative approach the highest level of risk has been assigned resulting in many of the areas being categorised as being at a high risk from surface water flooding. However the Proposed Scheme will mitigate surface water run-off to ensure that the works are at an acceptable level of flood risk and do not result in an increased risk elsewhere.

8.6.3 The Proposed Scheme will involve development within an area at a low risk from groundwater flooding. However the design involves measures to ensure that the development is an acceptable level of risk and that the Proposed Scheme does not increase flood risk from this source.

8.6.4 There is a low to medium risk of flooding from the sewer network to the Proposed Scheme including the route, other design elements and the temporary works.

However the works will be completed in line with the CoCP and hence will ensure that the Proposed Scheme and neighbouring areas will not be at an increased flood risk from this source.

8.6.5 The Proposed Scheme does not cross any canals in this study area and hence there is no risk of flooding from this source. Due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the Proposed Scheme is considered low.

9 Conclusions

9.1.1 The Proposed Scheme, including the route, other design elements and the temporary works, are to be located within areas at risk from flooding from a range of sources. However the temporary works will be designed to and will follow the CoCP such that development will be at an acceptable level of risk and will not cause an increased risk elsewhere. The proposed mitigation as part of the permanent works will also ensure that the Proposed Scheme will be at an acceptable level of flood risk and will not result in an increased risk elsewhere.

9.1.2 The magnitude of impact and significance of effects have been based on the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR), see Volume 5: Appendix CT-001-000/1. Table 10 shows a summary of the sources of flood risk within this study area and the associated magnitude of impact and significance of effects.

9.1.3 In terms of river flooding, the magnitude of impact in this study area of the Proposed Scheme with the floodplain replacement storage is minor and the significance of effects is considered slight adverse and therefore not significant.

9.1.4 Although there are areas of the Proposed Scheme at no, low, medium and high risk from surface water flooding, overall the risk from this source is categorised as high, as a conservative approach. However the overall magnitude of impact is negligible and the significance is neutral. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 2.6.23 of this report and the temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.5 Groundwater flood risk has been assessed as low.

9.1.6 The risk from sewer flooding is low to medium within this study area, and the overall magnitude is negligible with a neutral significance. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 2.6.23 of this report and temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.7 In this study area artificial sources of flooding (both from reservoir failure and canals) have also been categorised as low, resulting in a low significance of effect.

Table 10: Summary of Flood Risk Receptors showing the overall magnitude of impact and significance of effects

Flood risk receptor	Risk category	Magnitude of impact	Significance of effects
Areas at risk from river flooding	Very High	Minor	Slight adverse
Areas at risk from surface water flooding	High	Negligible	Neutral
Area at risk from groundwater flooding	Low	Negligible	Neutral
Areas at risk from drainage and sewer flooding	Medium	Negligible	Neutral
Areas at risk of flooding from artificial sources	Low	Negligible	Neutral

9.2 Residual flood risk to the Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from river sources

Coleshill west and east viaducts

9.2.2 River flood risk at this location is dictated by water levels in the River Cole, rather than the two ordinary watercourses which are tributaries of the River Cole. There is one hydraulic structure in close proximity to the Coleshill west and east viaducts and this is located immediately downstream of the Proposed Scheme. However, the viaducts will be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

River Cole west and east viaducts

9.2.3 There are two hydraulic structures in the vicinity of the River Cole west and east viaducts. One is the existing M42/M6 crossing over the River Cole, which is located downstream of the Proposed Scheme. However, the River Cole west and east viaducts would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

9.2.4 Upstream of the proposed crossing is the proposed Manor Drive realignment. As part of these highways works, there will be a crossing over the River Cole immediately upstream of the proposed River Cole west and east viaducts. There is potential that failure of the road bridge will impact on flood risk at the location of the viaducts, however the viaducts will be at a sufficient height above the floodplain to prevent a risk to the track.

M42 Coleshill south viaduct

9.2.5 There is one hydraulic structure in the vicinity of the M42 Coleshill south viaduct. This is the existing M42/M6 crossing over the River Cole, which is located downstream of the Proposed Scheme. However, the proposed viaduct would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

Coleshill culvert

9.2.6 At the location of the proposed Coleshill culvert, there are no significant hydraulic structures within the vicinity of the Proposed Scheme that would create additional residual risks to the Proposed Scheme.

Water Orton culvert

9.2.7 There is one hydraulic structure in the vicinity of the Water Orton culvert. This structure is an existing access track crossing the ordinary watercourse at this location. However the Proposed Scheme will include slight realignment of the watercourse,

and track embankments at the existing structure, such that access track will not cross this ordinary watercourse following completion of the scheme. Therefore there will be no residual risk to the Proposed Scheme from this existing structure.

River Tame viaducts

9.2.8 There are hydraulic structures located both upstream and downstream of the River Tame viaducts. However, the proposed viaduct would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

Residual flood risks from surface water sources and minor watercourses

9.2.9 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 300mm above the design flood water level to minimise the risk of blockage. Therefore, there are not expected to be any significant increases in risk of flooding at dry valley crossings arising from potential blockage of culverts.

Residual flood risks from groundwater

9.2.10 Groundwater levels rise and fall relatively slowly, and therefore any change in the risk of flooding from this source would be the result of below ground intervention. The risk of groundwater flooding already considered in this FRA presents an absolute risk, and there are no significant residual risks arising from this source.

Residual flood risks from the sewer network

9.2.11 Blockage of the sewer networks can cause surcharge and associated flooding. At locations where the existing sewer infrastructure will need diverting, any replacement infrastructure would be to at least the same standard as existing. Consequently, no additional residual risk to the Proposed Scheme would be expected as a result of drainage system failure.

Residual flood risks from artificial and surface sources

9.2.12 This assessment considers the potential for total failure of reservoirs and canals, which is deemed to be the most extreme case of flooding from these sources. Therefore it is considered that there are no further residual risks from artificial sources of flood risk.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 All culverts within the Proposed Scheme will be designed to convey the 1 in 100 year (1% annual probability) flow including an allowance for climate change with a minimum internal headroom of 300mm above the design flood water level (to minimise the risk of blockage). Consequently, there would be negligible increase in upstream residual flood risks arising from the introduction of culverts within the Proposed Scheme.

9.3.2 All viaducts within the Proposed Scheme will also be designed so that the 1 in 100 (1%) annual probability flow with an allowance for climate change can pass underneath. As a minimum the design will ensure a 600mm freeboard will be provided to the bridge soffits above this level, and on main rivers where possible, a freeboard of 1m will be

allowed. These freeboards will allow for debris and hence prevent a significant increase in residual risk in upstream areas as a result of the Proposed Scheme.

10 References

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